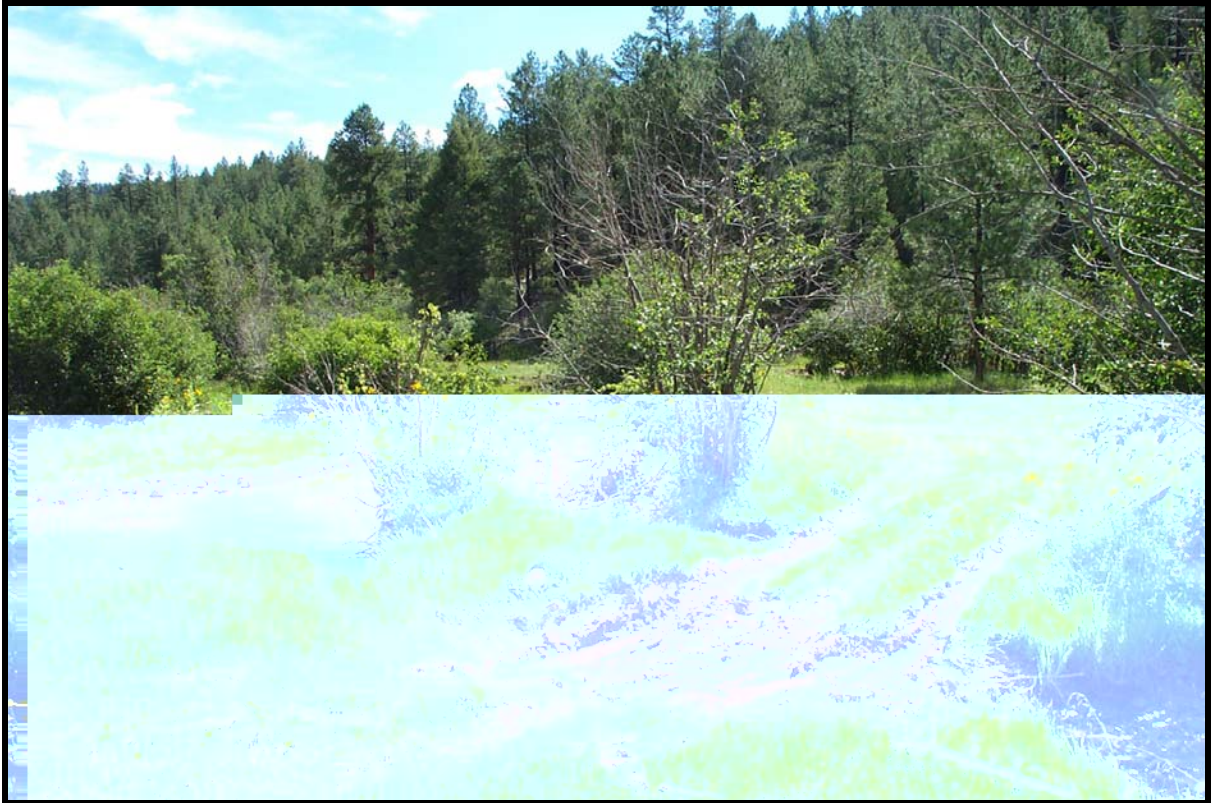


Rio de las Vacas

Stream and Riparian Restoration Plan and Recommendations



Prepared for the

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By

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Executive Summary

In June of 2002, Forest Service personnel from Regions 3 and 6 visited sections of Rio de las Vacas in northern New Mexico to discuss and prioritize stream and riparian restoration work that would improve habitat for the indigenous fish assemblage, particularly Rio Grande cutthroat trout. As a result of past land management, coupled with a flashy flow regime, stream and riparian conditions are degraded and characterized by high water temperatures, high width to depth ratios, lack of woody riparian vegetation (especially willow and alder) a lack of channel and flood prone area LWD, lack of pool habitat, low amounts of spawning sized gravel, and high amounts of fine sediment. The overall goal of the habitat restoration is to enable re-colonization of the entire stream by the native fish assemblage.

Overall restoration goals were identified and reach specific objectives were drafted. The two primary restoration goals were to reduce summer and fall water temperatures and decrease average bankfull width to depth ratios. Strategies to restore habitat varied, but increasing the amount of stream channel and riparian large woody debris and promoting woody riparian vegetation establishment and growth were key components of the overall plan. Restoring habitat in the headwaters first and progressing down to the Forest boundary would allow Rio Grande cutthroat trout to begin colonization downstream, and improved habitat conditions upstream would help mitigate degraded conditions (particularly high water temperatures) downstream. In addition to habitat restoration the repair/improvement of an existing man-made upstream migration barrier, designed to prevent non-native brown and rainbow trout from migrating into areas occupied by cutthroat trout, as well as possible locations of a new barrier downstream were evaluated.

Introduction

Santa Fe National Forest (SFNF) fisheries personnel have embarked on an ambitious restoration plan for the Rio de las Vacas designed to improve habitat conditions so that Rio Grande cutthroat trout, a Forest Service Region 3 sensitive species, as well as Rio Grande chub and Rio Grande sucker can reside from the mouth upstream to the headwaters. Current distribution of the Rio Grande cutthroat trout is limited to the upper 10 miles of stream within the watershed. Rio Grande chub, suckers and longnose dace are found primarily in the lower 11 miles of the las Vacas.

Fisheries personnel from the SFNF – Sean Ferrell, James Simino, and Matt Andre – along with Gary Asbridge from Region 6, visited sections of Rio de las Vacas from the mouth upstream to Rio las Vacas Campground on June 3, 4 and 5, 2002. We discussed a variety of restoration ideas and techniques that could be used to improve habitat conditions in the las Vacas. We also discussed the relative priority of various stream reaches, realizing that the restoration of the las Vacas is a long-term effort that could take a decade or more to complete and even longer to fully recover.

This report summarizes findings of field reviews conducted in early June 2002 and outlines goals, objectives, and potential restoration methods. The recommendations presented in this report are just that, recommendations. They reflect the ideas and experience of the author and are meant as guidelines to be used by SFNF personnel for planning, design and implementation of stream and riparian restoration projects in the Rio de las Vacas.

Watershed Background

The Rio de las Vacas is a spring and snowmelt fed stream that is subject to flashy flows due primarily to the non-porous granitic geology and the loss of wetland habitat that historically acted as a “sponge” to store and slowly release water. There is no hydrograph data for the watershed so the normal range of stream discharge is unknown. Based on a relatively recent report on water temperature total maximum daily load standards by the New Mexico Department of Environmental Quality the Q_2 stream flow (i.e. bankfull flow) is approximately 2.5 – 3.5 cubic feet per second depending on where one is in the watershed. These flows were calculated based on regional hydrograph curves and watershed area. The Jemez Springs Ranger District hydrologist has also estimated the Q_2 , Q_5 , Q_{10} , Q_{25} , Q_{50} and Q_{100} return interval flows for 1, 6 and 24-hour storm events.

The las Vacas downstream of the lower end of Reach 9¹ near the Rio las Vacas Campground is a relatively low gradient stream (< 3%) that flows through a combination of meadow and forested habitats. The watershed has been heavily impacted by a variety of land management activities including cattle grazing and logging. Much of the large woody debris (LWD) and beaver dams historically present in the channel were removed either during logging operations or at the direction of fisheries biologists who at the time considered these habitat elements to be barriers to upstream fish migration. The forested reaches (1-3, parts of 6 and 8) likely had relatively high amounts of LWD at least in certain areas prior to the removal described above. Cattle grazing, particularly in the meadow reaches, has contributed to a loss of woody riparian vegetation (willow and alder) in and along much of the stream channel. Native surface and aggregate roads are common and many are located in the valley bottom. Dispersed campsites adjacent to the stream are also common in many reaches, and in many cases there are unauthorized, non-system “ghost” roads leading to these campsites.

As result of the aforementioned land management, coupled with the flashy flow regime, the Rio de las Vacas has degraded habitat conditions characterized by high water temperatures, high width to depth ratios, lack of woody riparian vegetation (especially willow and alder) a lack of channel and flood prone area LWD, lack of pool habitat, and high amounts of fine sediment. Over time the lack of structure and roughness elements in the channel and floodplain (including riparian vegetation) have resulted in the stream either migrating laterally and/or incising downward. This in turn has reduced the amount of side channel habitat and the frequency of floodplain inundation that has caused drying of the flood prone area and led to encroachment of drier site adapted vegetation. High width to depth ratios have certainly contributed to elevated water temperatures as well as reducing the quantity and quality of pool habitat. Since there is little roughness in the channel the higher stream flows tend to exacerbate the erosive process, primarily in a lateral direction, and there is very little cutthroat sized spawning gravel because most of it is transported downstream out of the stream system.

Restoration Goals

The overall goal for the proposed restoration in the Rio de las Vacas is to re-establish the native fish assemblage from the headwaters to the mouth. In this case the native fish assemblage includes Rio Grande cutthroat trout, Rio Grande chub, Rio Grande sucker and longnose dace. At present however, much of the habitat downstream from Reach 9 would not support cutthroat trout, at least in high numbers, largely due to high water temperatures,

¹ Stream reach designations and descriptions are based on the *Rio de las Vacas Stream Inventory Report*, Santa Fe National Forest, March 2002.

a lack of suitable spawning and rearing habitat, and the presence of non-native salmonids². Therefore, there is a recognized need to prepare habitat to support the entire fish assemblage, particularly cutthroat trout.

Based on the known land management history of the watershed, 2001 stream survey data, and personal observations, the author and SFNF fisheries personnel arrived at the habitat restoration goals listed below. Note that these goals apply only to survey Reaches 1-8. The majority of Reach 9, at least the sections we visited, appears to be within the range of natural condition given that there has been little to no land management within or along the reach. Except for the short section downstream of Rio las Vacas Campground (see the Reach 8 discussion) and migration barriers the author does not feel channel or riparian restoration is warranted in Reach 9.

Habitat Restoration Goals

- Reduce summer and fall water temperatures.
- Decrease bankfull width to depth ratios.
- Increase the quantity and quality of pool habitat.
- Increase the amount of large woody debris in the channel and floodplain where appropriate.
- Increase the amount of side channel habitat where possible.
- Increase the amount of suitable cutthroat spawning habitat (i.e. gravel).
- Decrease the amount of fine sediment (sand, silt, clay) in the bankfull channel.

Of the goals listed above it is the professional opinion of the author that the first two are the most important in terms of restoring habitat that would be usable by cutthroat trout. Decreasing the width to depth ratio in particular would not only help reduce water temperatures but would lead to increasing pool quantity and quality and increasing the amount of suitable spawning habitat. As outlined below, other goals would be met by restoration techniques to reduce width to depth ratios.

The author strongly believes the best approach to habitat restoration within the Rio de las Vacas watershed is a “top down” approach. Beginning with Reach 8 and moving downstream would restore habitat closest to the current stronghold of cutthroat trout and would better enable them to migrate and colonize downstream. Restoring the upstream reaches would have the added benefit of correcting problems, such as sediment sources and increasing stream shade, that would mitigate degraded conditions downstream. However, as opportunities present themselves to complete needed work in downstream reaches they should be acted upon lest the opportunity pass.

No restoration effort in a stream used and valued by the public can be completely successful without education of forest users so they understand why the project is important and the benefits. Therefore, another goal associated with the restoration project is to educate local landowners, forest users and Forest Service personnel concerning the reasons why the restoration is important and the expected benefits.

² The author recognizes that non-native salmonids, primarily brown trout but also rainbow trout, have a deleterious effect on the native Rio Grande cutthroat trout. Removal of these species is a critical component of the overall restoration plan and successful colonization of the lower reaches by cutthroat trout will likely not occur without the eradication of these non-native species. However, with the exception of recommendations relating to maintenance or construction of migration barriers, this report will focus on habitat restoration only and not species eradication.

Reach Specific Conditions and Restoration Objectives

This section of the report is devoted to brief descriptions of each reach where restoration is proposed and site-specific objectives designed to move the watershed towards meeting the habitat restoration goals outlined above. Note that the reach descriptions below are based on personal observations by the author during site visits in early June 2002. For more detailed information about current habitat conditions refer to the *Rio de las Vacas Stream Inventory Report*, March 2002. Commensurate with the “top down” restoration approach, the reaches are listed beginning with Reach 8 and working downstream.

The objectives below were based on the overall habitat restoration goals discussed previously and were formulated by the author and the SFNF fisheries personnel mentioned above. Many of the objectives are not yet finalized in that more baseline information needs to be collected to determine the appropriate target. For example, the author believes width to depth ratios outlined in the 2002 stream survey report are not indicative of overall reach conditions because width to depth ratio was only measured once in each reach. Timelines for the objectives to be met also need to be established where appropriate. Fisheries personnel from the SFNF will be collecting the appropriate information over the course of this field season to finalize site-specific objectives and timelines for completion. As this additional data is collected and some logistical considerations are finalized some of the objectives may be modified or possibly dropped pending new information.

Reach 8

Reach 8 was a short meadow reach (< 0.5 miles in length) that had multiple channels due in part to a logjam in the lower section of Reach 9 that has caused a channel avulsion (Figure 1). It appears the channel has incised in several areas and the width to depth ratios are likely higher than in the past. There is a stand of timber to the south of the main channel that likely provided LWD to the channel and flood prone area historically (there were cut stumps in this stand) and LWD was also transported downstream from Reach 9 (as evidenced by the logjam mentioned above). The substrate is relatively large, cobble and small boulder, with low amounts of smaller gravel that provide suitable spawning habitat for cutthroat trout. More than likely the smaller gravel is transported through the reach during higher flows as there is limited roughness. It is the opinion of the author that this entire reach was likely a wet meadow complex prior to the channel incision and increased width to depth ratio caused by the removal of natural roughness elements.

There is an excellent opportunity here to re-establish the wetland complex by placing several well placed logjams in the main channel and also placing wood in the flood prone areas (low spots). The logjams would cause the channel to aggrade and allow for more frequent flood prone area inundation, as well as re-water or create new side channel habitat. This wood placement in and outside the channel would also facilitate deposition of finer substrates that would increase the retention of spawning sized gravel as well as sand and silt that would improve conditions for riparian vegetation establishment. The author believes this reach provides the best opportunity to create excellent salmonid habitat in a relatively short period of time (< 5 years depending on precipitation and stream flows) of all the reaches proposed for restoration.

Logjams in the channel should be placed in areas where channel aggradation would result in inundation of nearby flood prone areas. Valley wall to valley wall cross sections would help identify the true low spots where flood prone area wood should be placed and also help determine final logjam locations. The cross sections, coupled with return interval flow estimates, could also be used to predict the area of inundation at different flows.



Figure 1. A natural logjam located approximately 200 feet upstream from the Clear Creek/ Rio de las Vacas confluence. The logjam has caused a channel avulsion (left side of photograph) that has created a side channel that likely provides excellent habitat when water flows through it.³

It would be unadvisable to treat this reach with LWD unless there is enough to place wood both in the bankfull channel and in the surrounding flood prone areas (Figure 2). If wood is placed in the bankfull channel only then there is a real risk of channel avulsions. Although this would create side channel habitat the roughness provided by additional LWD in the flood prone area would reduce the chance for accelerated incision and associated erosion plus provide habitat for fish at a variety of flows. Access is excellent in this reach for heavy equipment and log trucks. Care needs to be taken to protect the telephone/power lines and poles, as well as a gas line that is buried and runs through the reach.

Site-specific objectives for Reach 8 include:

1. Reduce the average bankfull width to depth ratio to 12 - 15.
2. Increase the amount of stream shade.
 - a. A baseline survey needs to be conducted to determine current conditions before a target can be established.
3. Reduce the amount of fine sediment in riffles to 20% of the total or less.

³ Note: Photos in this document were taken during peak drought conditions in June 2002 (unless otherwise noted) and are not representative of typical flows.

4. Increase the amount of LWD in the bankfull channel to at least 30 pieces per mile and 60 pieces per mile in the flood prone area.
 - a. Needs to be determined on a reach-by-reach basis what the appropriate level is.
5. Increase the amount of pool habitat to 30% or more of the total habitat present.
 - a. Residual depth (i.e. pool quality) meets the Forest standard but may be on the edge due to fine sediment filling pools.



habitat, larger substrates, and very little woody riparian vegetation. It is unlikely this reach naturally had large amounts of LWD in the channel and flood prone area historically but the author believes LWD was likely present (more than now certainly), either routed from upstream reaches or from the occasional conifers or cottonwoods falling into or near the channel. In some areas in Reach 6 the channel was actually quite close to forested hill slopes and it is quite probable that trees fell into or along the channel with some regularity. Pines were also relatively abundant on the old terrace (Figure 3).



Figure 3. A representative photograph of Reach 6 that illustrates the relative channel confinement between old terraces. Woody riparian vegetation (willow and alder) is generally lacking although some areas are starting to recover. Note the larger substrate and wide, shallow channel that is indicative of much of Rio de las Vacas.

Restoration efforts in this reach should focus on reducing the width to depth ratio and promoting woody riparian vegetation growth. Wherever possible, the stream and associated flood prone area should be fenced to prevent cattle access. Areas both within and outside fenced exclosures could be planted with willow, alder or cottonwood to speed vegetation recovery. Over time, the encroachment of riparian vegetation will result in a narrower, deeper stream channel. However, this will take years (likely 10 or more) and will depend largely on adequate moisture, stream flows and keeping livestock out of the stream and riparian area. Proper construction and maintenance of fences must be a priority. The existing exclosure should be maintained prior to any new fence construction.

As with all grazing operations on Forest Service land, the fisheries biologists should work closely with the range conservationist to modify and amend allotment management plans and annual operating instructions as needed to reduce the impact cattle have on streams. Rest rotation grazing strategies, or something similar, should be considered if not already in place.

There is also an opportunity here to speed recovery by placing wood and/or boulders along stream margins. These “margin jams” would act to concentrate flow in a smaller area plus promote deposition of substrate behind the jam downstream. This bar development would in turn be an excellent place for vegetation establishment and the end result would be a narrower, deeper channel with more riparian vegetation. Spawning sized gravel would also tend to collect and be sorted downstream of the margin jams. Note that in the wider, flatter areas some flood prone area wood placement would be advisable in the event channel avulsion occurs. However, margin jams, as opposed to channel spanning jams as recommended in Reach 8, would be much less likely to completely dam the stream and result in channel avulsions. Margin jams should not encroach into the bankfull channel more than 1/3 of the total width.

Site-specific objectives for Reach 6 include:

1. Reduce the average bankfull width to depth ratio to 20 or less.
2. Increase the amount of stream shade
 - a. A baseline survey needs to be conducted to determine current conditions before a target can be established.
3. Reduce the amount of fine sediment in riffles to 20% of the total or less.
4. Increase the amount of LWD in the bankfull channel and flood prone area to an amount within the range of natural conditions.
 - a. Needs to be determined what the appropriate level is.
5. Increase the amount of pool habitat to 30% or more of the total habitat present.

Reach 5

This reach is non-accessible private land, and therefore it was not evaluated.

Reach 4

The valley is wider in Reach 4 compared to Reach 6 and the low gradient stream flows through a large meadow. Woody riparian vegetation is lacking which has resulted in little shade, increased width to depth ratio, and channel incision in some areas (Figure 4). Cattle grazing has likely been the largest human related deleterious impact on the stream and riparian landscape in this reach. Dense coniferous stands likely were never prevalent in the valley bottom so riparian timber harvest was minimal if it occurred at all. Beaver and beaver dam removal likely occurred in this reach in the past. We saw little evidence of beaver at present, possibly due in part to a lack of forage.

The primary restoration goal in this reach is to re-establish woody riparian vegetation that would in turn lead to increased stream shade and, over time, a narrower and deeper channel. Since LWD was likely never a primary habitat forming component in this reach the best way to reach this goal would be to limit access to the stream and riparian area by cattle. Some of the riparian area and stream channel in this reach has already been fenced to exclude cattle. Although the woody riparian vegetation shows signs of recovery in this section compared to unfenced areas the fence we saw was in need of repair and it is likely cattle have been grazing inside the enclosure. Repair of this fence should be the number one restoration priority in this reach, followed by construction of new enclosure fences where possible. Water sources outside the riparian area, if available, should be developed to provide water for cattle away from the Rio de las Vacas.

There were several sections of vertical stream bank in this reach that was actively eroding (Figure 5). Other sections had sloughing banks that could lead to vertical stream banks if

cattle are allowed to continue grazing in the riparian area and/or the banks aren't stabilized by vegetation. Pulling these vertical banks back



Figure 5. Actively sloughing and vertical stream banks in Reach 4 of Rio de las Vacas not only contribute fine sediment to the stream channel but also retard woody riparian vegetation establishment. (Photo taken 8 Aug 2001)

Reach 3

Reach 3 includes the Rancho Chaparral Girl Scout Camp, wherein the stream channel is relatively constrained with a coniferous forest riparian vegetation component, and a more unconstrained reach upstream that flows through a mixture of meadow and forested habitats. There was more LWD in the bankfull channel here than in other reaches, although the reach did not meet Forest standards for LWD/mile. Upstream of the Girl Scout Camp there was more fir and spruce present in the riparian area than downstream reaches. The public sections of this reach and downstream marked the beginning of the majority of the dispersed campsites along the creek. There were several dispersed sites and “ghost” roads adjacent to the creek.

The dispersed sites should be moved away from the creek or removed entirely. Many of the dispersed sites are located within, or adjacent to, the flood prone area and most likely contribute fine sediment during higher flow events, because riparian vegetation is lacking and exposed mineral soil is common (Figure 6). Signs or other educational methods describing why each site is closed should be part of the treatment. Wood placement at the dispersed site in Figure 6 is recommended (after scarification) but the wood should be low profile to avoid undue pressure on the vertical bank on the west side of the channel and the road located on the east side of the channel (not shown in the photo). Pulling the west stream bank back to a lower angle of repose is an option to promote faster re-vegetation.

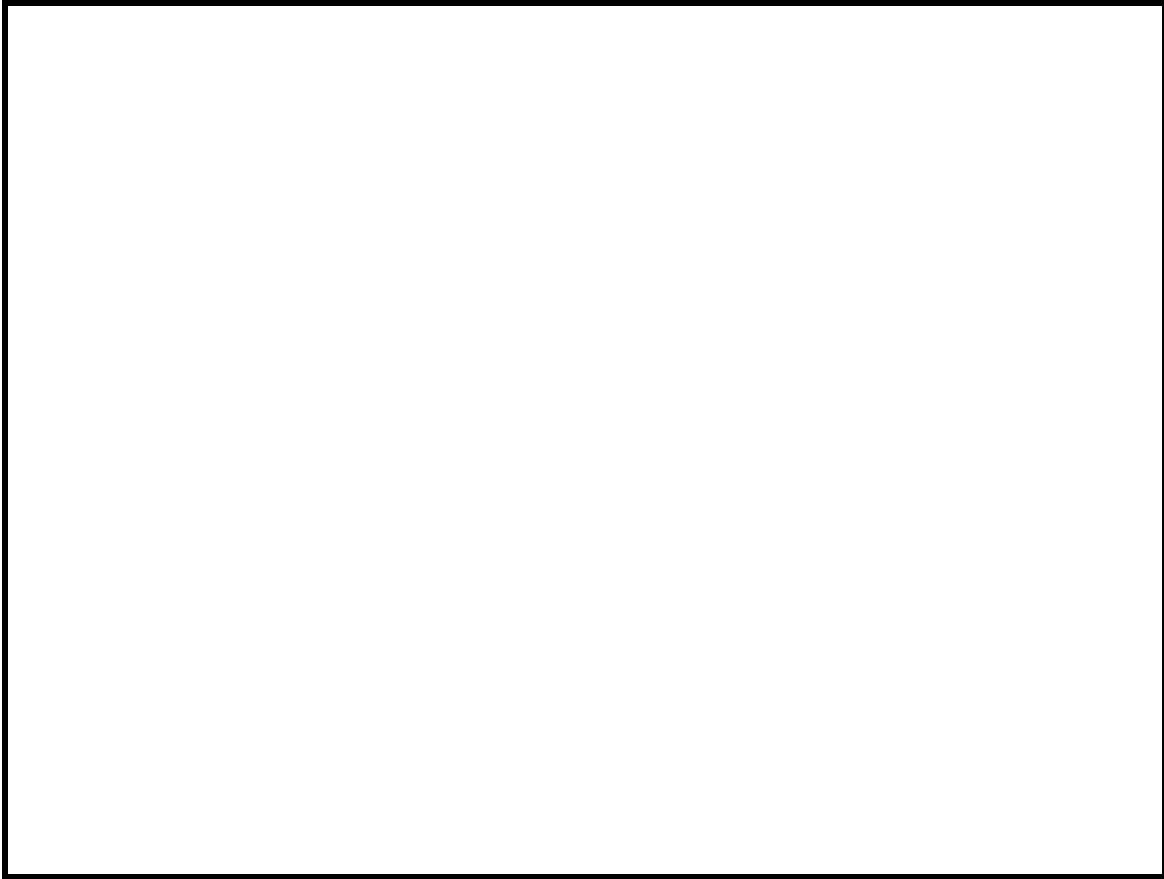


Figure 6. Dispersed site along the shores of Rio de las Vacas that should be completely obliterated. Scarification of the site, followed by LWD placement and planting of riparian dependent plant species would speed recovery of this site.

All ghost roads (in this reach and others) should be completely obliterated, planted, treated with LWD as appropriate and blocked at all intersections to prevent further access. Unneeded fords also merit the same treatment and may be more of a priority for removal/blockage than dispersed sites or ghost roads.

This reach has great potential to benefit from LWD placement, particularly in the more constrained, forested sections where there are already some accumulations of old LWD. In fact, the best template for margin LWD placement is located in this reach near the downstream boundary of the Girl Scout camp (Figure 7). This natural margin jam has caused a downstream bar to form that is now vegetated and this bar has resulted in a smaller width to depth ratio in the channel downstream of the logjam. This is the objective of virtually all channel margin LWD and/or boulder placement recommended for Rio de las Vacas. Placement of LWD to mimic that shown in Figure 7 should result in a narrower and deeper channel over time. Much of the LWD for this section (and perhaps elsewhere) could come from the ongoing thinning in the Girl Scout camp.

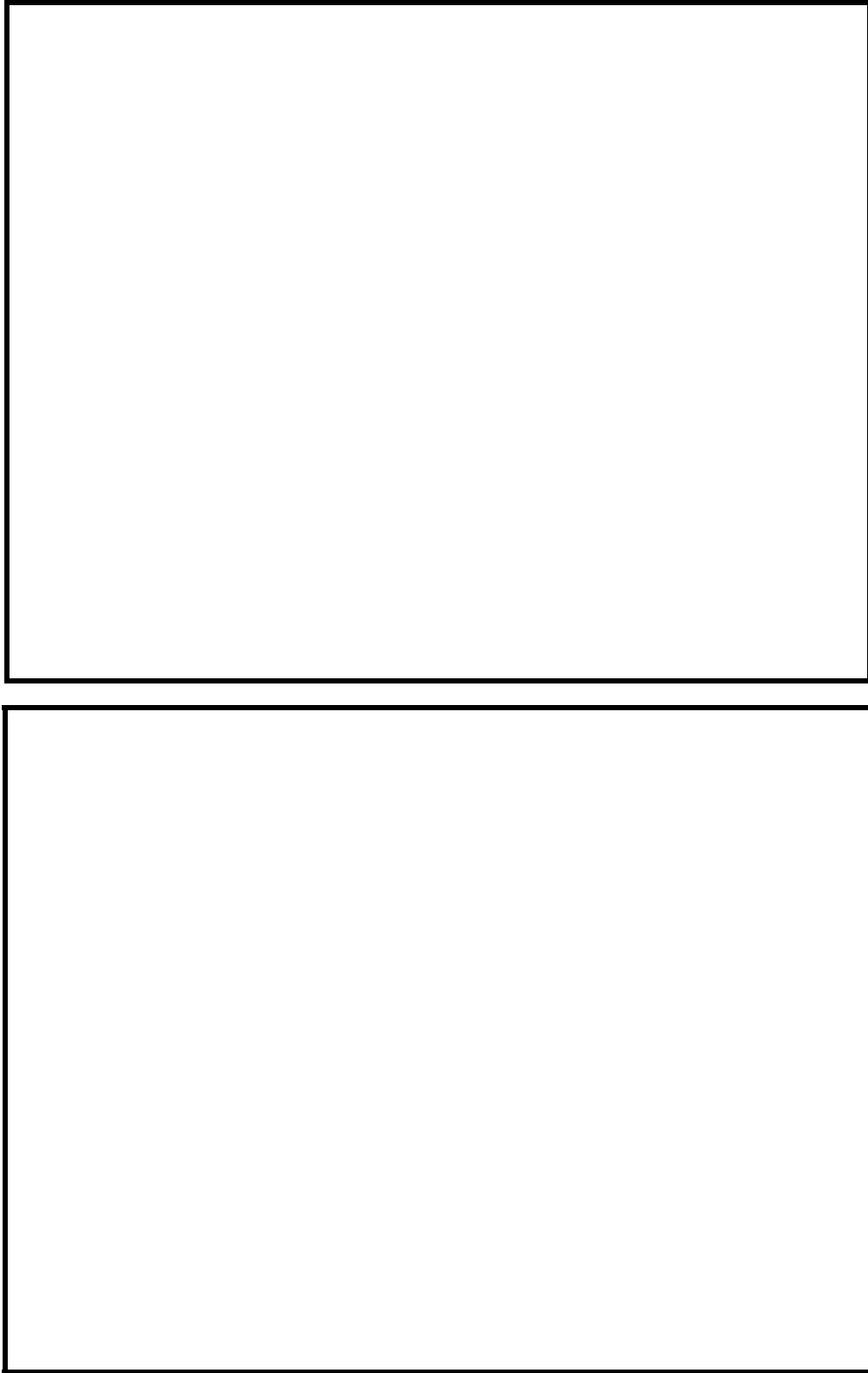


Figure 7. Photographs of a natural logjam along the channel margin in the Rio de las Vacas from an upstream vantage point (top photograph) and downstream vantage point (bottom photograph). Note the bar that has formed downstream and the grass and alder growing on it. The channel has become narrower below the logjam due to the bar formation.

This reach, and downstream reaches, has constraints that need to be considered if LWD is placed in the channel and flood prone area; namely valley bottom roads and telephone/power lines. Along 90% of the stream length within the Girl Scout Camp there is a road that lies adjacent to the stream channel. Whether to keep or remove this road is an important decision that will help determine the appropriate treatment because placement of LWD will cause the stream to shift and potentially blow out the road in places. If the road is to remain then care must be taken to protect the road prism. Placement of LWD will be easier if the road can be decommissioned since channel migration would be less of a concern. There are other sections of this reach, outside the Girl Scout Camp, where a mainline road lies adjacent to or within the riparian area. This road will need to be protected and LWD placement will need to be carefully designed to avoid road failure at higher flows. Protection of any and all roads alongside the creek could be accomplished in a variety of ways, including placement of LWD or boulders d

The bridge across the Vacas just upstream from the Girl Scout Vamp has relatively little cross sectional area and therefore may not allow large amounts of debris to flow through during flood events. If LWD is placed upstream from this bridge some form of anchoring, or construction of a logjam designed to trap and hold debris should be considered. The logjam would have to be located in a site that was relatively constrained to reduce the chance of channel avulsion upstream of the logjam.

There are also some unconstrained meadow sections in Reach 3 that have similar problems as those described in Reaches 4 and 6. As recommended for those reaches, fencing off as much of the riparian area, or some other method of keeping livestock away from the channel, would be the most cost effective method of restoration. Placement of LWD in certain areas is possible but subsequent channel migration needs to be considered and planned for.

Reach 3 objectives are related to constrained and unconstrained sections:

Constrained Sections

1. Reduce the average bankfull width to depth ratio to 20 or less.
2. Increase the amount of stream shade.
 - a. A baseline survey needs to be conducted to determine current conditions before a target can be established.
3. Reduce the amount of fine sediment in riffles to 20% of the total or less.
4. Increase the amount of LWD in the bankfull channel and flood prone area to at least 30 pieces per mile.
 - a. Needs to be determined what the appropriate level is.
5. Increase the amount of pool habitat to 30% or more of the total habitat present.

Unconstrained Sections

1. Increase the amount of stream shade.
 - a. A baseline survey needs to be conducted to determine current conditions before a target can be established.
2. Reduce the average bankfull width to depth ratio to 20 or less.
3. Re-introduce cottonwood to the riparian system.
4. Re-introduce beaver once woody riparian vegetation is established.
5. Increase the amount of pool habitat to 30% or more of the total habitat present.

Reach 2

Rio de las Vacas in Reach 2 is similar to Reach 3 in that there is an unconstrained reach (O'Neil's Landing) in the upper section and then the river flows into a more constrained section downstream. The more constrained section does contain some areas that widen out and have meadow characteristics although none are as wide as meadow reaches upstream. Dispersed sites are relatively abundant and Forest Service Road 539 (new) parallels the creek for much of its length. There are also two non-system road fords within this reach.

Restoration in O'Neil's Landing should focus on re-establishment of woody riparian species that would provide more stream shade and eventually result in a smaller width to depth ratio. This meadow is actually better vegetated than most of the meadow habitat upstream (Figure 9) although more shade would be desirable. The most cost efficient way to complete this would be by fencing to exclude cattle along with the obliteration and re-vegetation of any dispersed sites and ghost roads in the area. Although this method of treatment will take

time to meet the site-specific objectives, it is the author's preferred option over treatment with LWD due to the large amount of wood needed (see below). Other meadow areas in Reach 2 could be treated in the same fashion as just described.

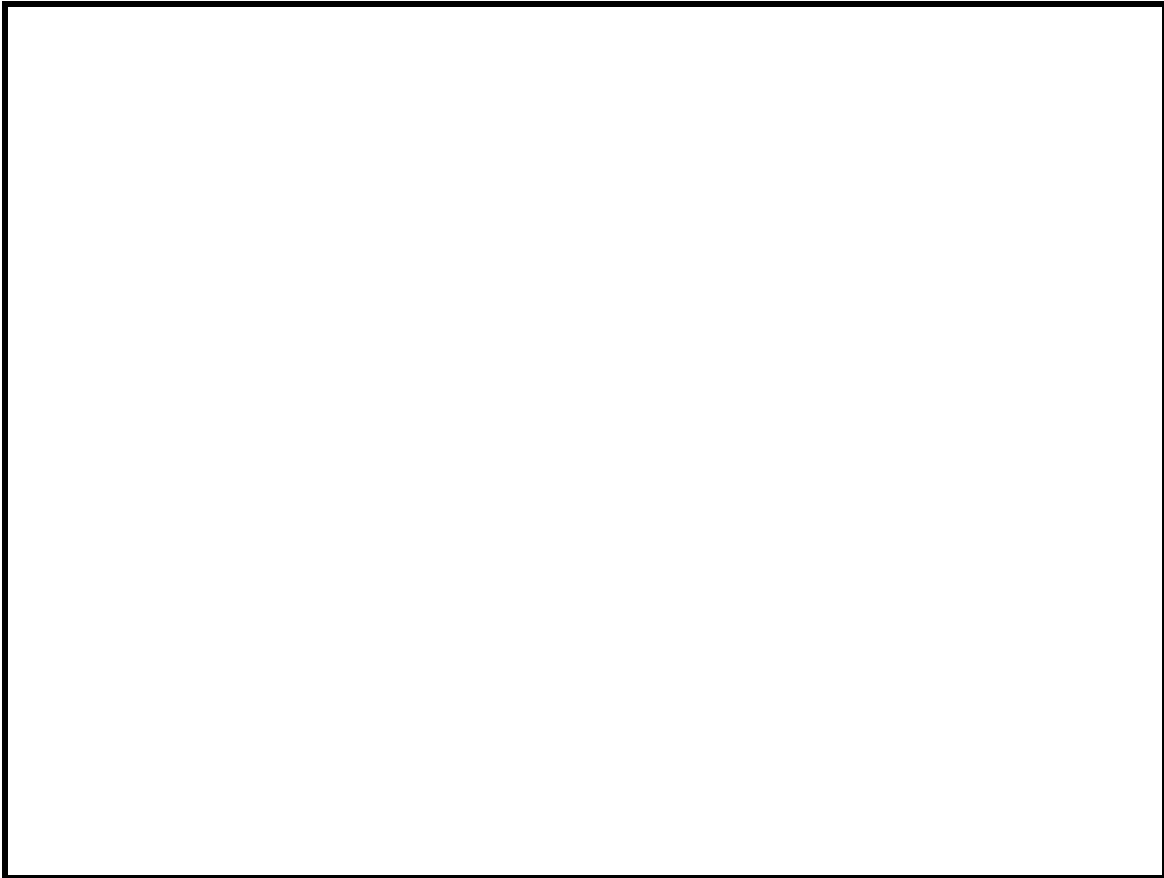


Figure 9. O'Neil's Landing located in Reach 2 of the Rio de las Vacas. Woody riparian vegetation is better established here compared to some meadow reaches upstream. Fencing of this area would result in even more rapid recovery of the vegetation by excluding cattle.

It is possible to treat O'Neil's Landing with LWD; however, any LWD placement in the channel would result in channel migration. Because of this it would be wise to treat the entire flood prone area with LWD to ensure there would be roughness present to reduce erosion and provide habitat in the event of a channel shift. This would take a very large amount of LWD and would likely be expensive. The benefit of this approach however is that it could speed recovery of the riparian area vegetation by aggrading the channel with a rise in the water table and more frequent flood prone area inundation.

The more constrained reaches in Reach 2 would benefit from the addition of LWD and/or boulders along channel margins as described for Reach 3. However, protecting the Forest Road 539 prism needs to be part of the design. Designing LWD placement to move the stream channel away from the road, if possible, would be the best long term solution but in the event that is not practical the stabilization of the road prism with vegetation, logs and/or boulders (not rip-rap) could suffice.

The two stream fords, as well as dispersed sites and ghost roads, should be obliterated and re-vegetated as soon as possible. At the fords an attempt should be made to reduce the

current width of the stream to approximate the bankfull width up and downstream by building new stream banks and planting riparian vegetation. These banks can be built in a variety of ways but the preferred method would be to use rock and/or LWD (these can be buried) with topsoil placed on top. The topsoil can then be planted with riparian vegetation.

Objectives for Reach 2 relate to the constrained and unconstrained sections:

Constrained Sections

1. Close the two fords and restore the stream channel to a bankfull width to depth ratio < 20.
2. Add large wood to meet or exceed the Forest standard of 30 pieces per mile within the bankfull channel.
 - a. Use fuelwood from Bales TS and/or riparian thinning of Ponderosa pine.
3. Increase the amount of pool habitat to meet the Forest standard of 30% of the total.
4. Reduce the average bankfull width to depth ratio to 20 or less.
 - a. Baseline needs to be established.
5. Decrease the amount of fine sediment in riffles to 20% or less of the total.
6. Increase the average amount of stream shade.
 - a. Baseline needs to be determined and then determine the target.
7. Obliterate and seed all non-system roads.

Unconstrained Sections (O'Neil's Landing)

1. Fence O'Neil's Landing meadow to prevent cattle access.
2. Increase the average amount of stream shade.
 - a. Baseline needs to be determined and then determine the target.
3. Re-introduce cottonwoods to the riparian area.
4. Re-introduce beaver into the area once woody riparian vegetation is established.

Reach 1

Rio de las Vacas in Reach 1 is very similar to the constrained section of Reach 2. The narrow valley and old and new Forest Service Road 539 confine the stream to a degree; although there are wider valley sections, particularly in the upstream portions of the reach. The old, closed 539 road in particular lies adjacent to the channel along much of its length. The stream channel itself was characterized by large, angular substrate (cobble and small boulder were dominant), low amounts of LWD, very little shade and a wide, shallow channel. There were three fords across the creek along the old 539 road; all have caused significant channel widening.

Opportunities for in-channel and flood prone area restoration in this reach are similar to those described for the more constrained sections of Reaches 2 and 3. Margin logjams and/or boulder placement would reduce the width to depth ratio over time as well as promote bar formation and woody riparian vegetation establishment. The natural margin logjam found in Reach 3 can be used as a template for LWD placement here. At least some of the LWD for this reach could come from riparian thinning in the vicinity or fuel wood from the Bales Timber Sale.

As in upstream reaches a decision needs to be made concerning both the old and new 539 roads. Since the old 539 road is closed to the public (although vehicles are getting around the gate at the lower end) the best option would be to completely obliterate and, if possible, re-contour the road prism to an angle that approximates the pre-road condition. Not only

would this completely remove the chance for vehicles to access the area but it gives project designers more options and locations where LWD and boulders can be placed since protection of the road wouldn't be necessary. However, protection of the new 539 road prism where it encroaches into the flood prone area, as described above in Reaches 2 and 3, will be necessary.

Associated with the road obliteration is the reconstruction of the stream banks at all fords. As described above, placing LWD and/or boulders along the margins and then filling with topsoil and planting would provide stable banks that would also allow vegetation establishment. Designers should strive to approximate the channel banks at all

Raise the entire barrier 6" or so. At present the east side is the weak point.

Remove the boulder pool control downstream and place the boulders in the pool to fill in the pool; the bigger the boulders the better.

Widen the channel downstream of the barrier by removing the boulder "bar" on the west side. This will make the stream wider and shallower resulting in less likelihood of a pool forming.

- Shore up the west bank below the barrier, where it looks as if high flows have eroded the bank, by placing the rock removed from the bar (see foreground, Figure 10).



Figure 10. A barrier built around 1980 in Rio de las Vacas designed to prevent non-native salmonids from migrating upstream.

Remove tree on the east bank below the barrier and the leaning snag on the east bank upstream of the barrier.

- Either place the LWD in the channel well downstream (100' or more) or use as high flow deflectors upstream of the barrier on the west bank on top of gabions (Figure 11, right side of photograph).

Remove gabions and replace with large boulders (one yard or more in size). Put boulders at least two deep and try and make as high as the cement retaining wall. Do not encroach into the stream cross sectional area here.

Consider removing the rocks and down tree on the west bank above the barrier to relieve the pressure on the east side of barrier (Figure 11, center).

Could re-route the thalweg to the middle of the channel and barrier by constructing a shallow V in the middle of the barrier when re-built. Might need to add some

deflectors on the left bank upstream to channel the flow (or a small logjam). This would cause the water to spill over the middle of the barrier as opposed to the east side where the water runs down a large boulder (there is speculation that at some flows brown trout may be worming their way up this boulder face). However, routing water over the middle of the barrier may cause more rapid deterioration of the barrier wall.

Maintenance will be required at this site over time.

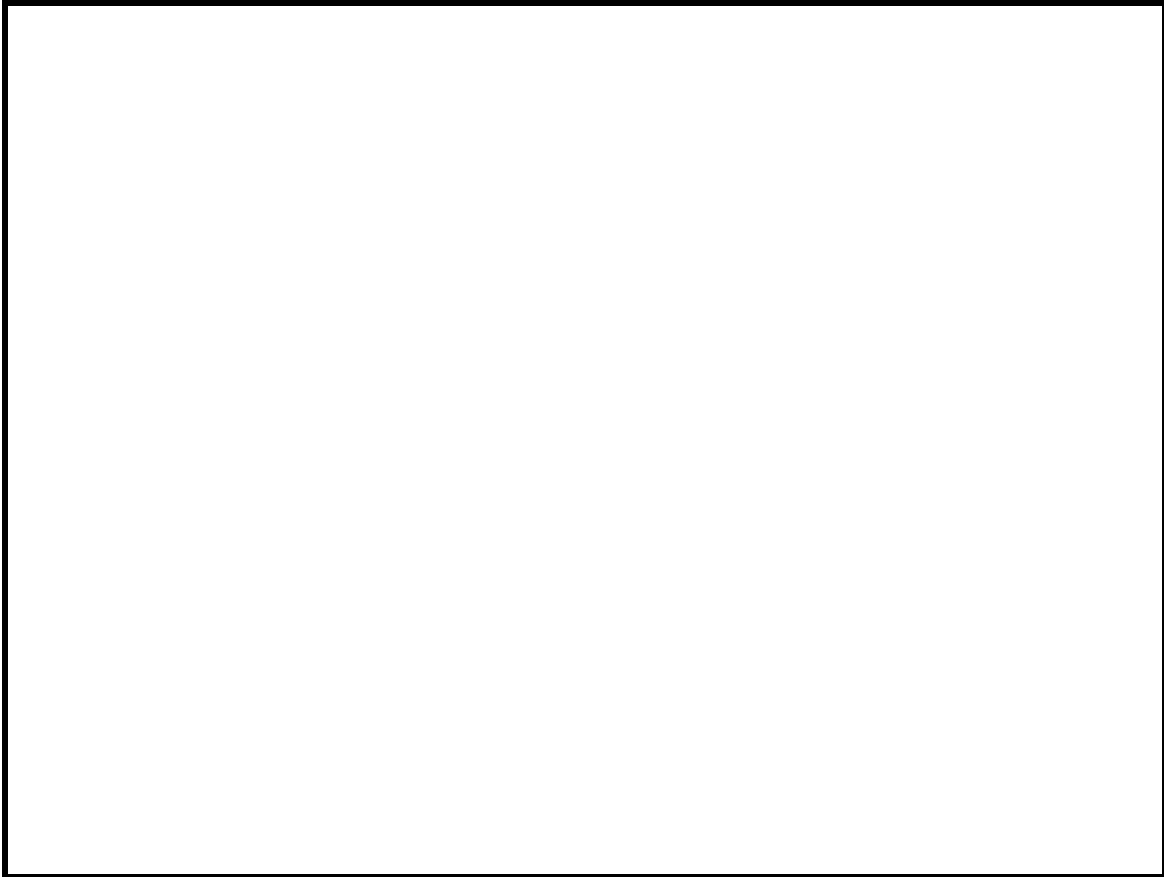


Figure 11. Looking downstream at the barrier in Rio de las Vacas built around 1980.

New Barrier Locations at the Lower End of Reach 9

We visited three locations near the lower end of Reach 9 where SFNF fisheries personnel are considering building another barrier. It was the author's opinion that the lowest and highest locations were best because they were either more confined and/or had better natural control points on the stream banks to tie the structure to. The site visited between the upper and lower sites will not be discussed here.

For several reasons the uppermost site may be best suited for the barrier. It was the furthest away from the Rio las Vacas Campground and had rock walls on both sides of the creek. However, the site is too far from the campground to provide for excavator access unless a walking excavator is used. The other option is to build the structure by hand. Although certainly possible it is the author's opinion that this could be very difficult because the site is relatively wide and handwork implies smaller material would be used which could reduce the long-term stability of the structure. It would be advisable to bring a masonry contractor to the site to get an accurate idea of the time, materials and difficulty involved. In

any event it would be best to try and design the barrier so that water spilling over the barrier fell on large boulders to prevent pool development.

The lowest site was immediately adjacent to the Rio las Vacas Campground. There may be a liability issue to consider because a large structure such as this would be a magnet for campers that want to swim or play in the creek. However, from a design perspective this was the author's preferred site because the channel was the most confined here and the gradient was steeper than in other areas (Figure 12). Since the banks were not rock walls as at the uppermost site there may be a need for some riprap but the overall disturbance area in terms of the structure to be built and the depositional zone behind it would be less here than at the uppermost site. This site is steep enough that it may be possible to construct a steep, relatively smooth chute as opposed to a waterfall to prevent fish migration upstream. A chute structure would be more efficient at routing sediment and LWD and thus would be less likely to blow out. As mentioned for the uppermost site, if a falls barrier were built it would be best to try and design it so that the water spilling over the top fell onto boulders to prevent pool development.

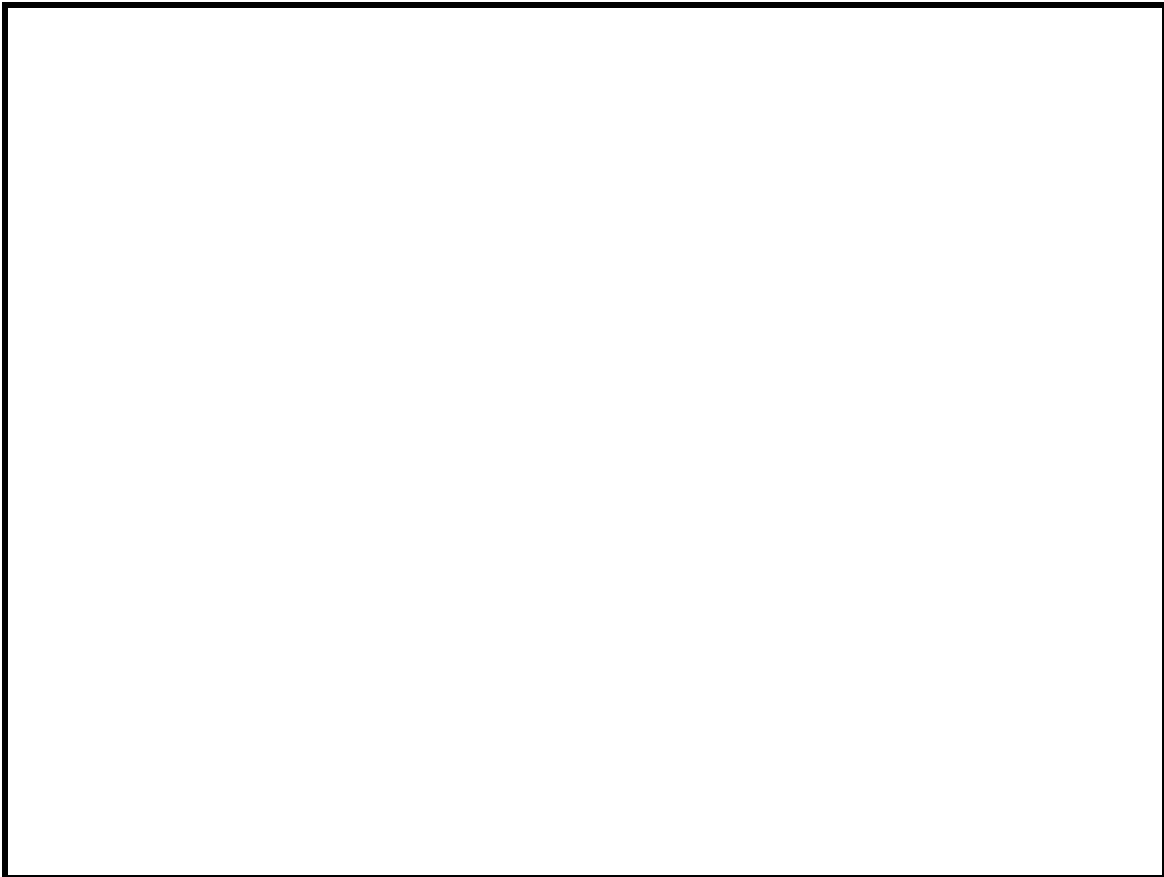


Figure 12. Potential site for fish barrier construction in the Rio de las Vacas near the Rio las Vacas Campground. The photograph is taken looking upstream.

Logistical and Planning Considerations

The following is a list of logistical and planning considerations that may be useful for project designers and implementers.

The amount of LWD available for each project reach is a critical piece of information that is needed. Until the designers know how much wood they have to work with it is difficult to arrive at a final design. Individual work sites should be prioritized so that the wood and boulders are placed in the key spots first.

Priority sites would generally be those where one would expect LWD to accumulate naturally, i.e. the wider, lower gradient depositional areas.

Use a service type contract that is essentially a time and equipment (with operator) rental agreement. This implies that a Forest Service inspector is on site at all times during construction to direct the operator(s).

Consider the order of the work to be performed. For example, in Reach 1 the old 539 road should be obliterated after wood is placed, or at the same time, so that the road can be used as access for log trucks. In some situations the access routes may need to be improved, even if they will be obliterated as part of the project.

Expect delays and plan for them. Restoration projects usually start slow and then efficiency increases and so does the pace of work.

Ensure that any equipment working in or around the stream has been cleaned, inspected for leaks, and carries a spill kit. FS personnel should also have spill kits.

If possible the COR should not be the primary person directing the equipment.

Have someone on site that can operate a chain saw, more than likely you'll need it. Buy half dozen or so chokers of various lengths (15-20 feet or so). Half inch or 5/8" diameter cable should be adequate. These will be needed to move and place logs. The best piece of equipment for this project would be a mid-sized track excavator (Caterpillar 320 or 325, or similar machine). Make sure the bucket has a thumb.